

entering into the minor details, will find in this little book a most useful guide. The author has dealt with the subject rather curtly, but nevertheless in this space the reader will find descriptions of various lanterns for different methods of projection; hints on the most suitable positions in which screens should be placed to be best viewed by audiences; the best kinds of burners for the lamps, both oil and oxy-hydrogen, and the different adjustments for producing good results. Many other useful hints are given, accompanied by several woodcuts. W.

### LETTERS TO THE EDITOR.

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#### Heat-Engines and Saline Solutions.

MR. MACFARLANE GRAY (p. 414) appears to call in question my assertion that in a vapour-engine a saline solution may take the place of a simple liquid when it is desired to replace water by a substance of less volatility, and that the advantage which Carnot proved to attend a high temperature can thus be attained without encountering an unduly high pressure. He contends that "the saline mixture is not the working substance. Carnot's law refers to the working substance only, and not to anything left in the boiler."

Perhaps the simplest way of meeting this objection is to point out that Maxwell's exposition of Carnot's engine ("Theory of Heat," chapter viii.) applies *without the change of a single word*, whether the substance in the cylinder be water, mercury, or an aqueous solution of chloride of calcium. In each case there is a definite relation between pressure and temperature; and (so far as the substance is concerned), all that is necessary for the reversible operation of the engine is that the various parts of the working substance should be in equilibrium with one another throughout.

Let us compare the behaviour of water in Carnot's engine before and after the addition of chloride of calcium, supposing that the maximum and minimum pressures are the same in the two cases. The only effect of the addition is to raise both the superior and the inferior temperatures. The heat rejected at the inferior temperature may still be available for the convenient operation of an engine working with pure water. At the upper limit, *all* the heat is received at the highest point of temperature—a state of things strongly contrasted with that which obtains when vapour rising from pure water is afterwards superheated.

RAYLEIGH.

#### Superheated Steam.

LORD RAYLEIGH touches on a most important question (February 18, p. 375), which merits the attention of all interested in the economy of prime movers. Few have troubled themselves with determinations of temperatures and pressures within a steam generator. Ebullition means work, and the performance of work involves cooling; hence the temperature of steam in the steam space of any boiler is lower by several degrees than the temperature of the steaming water. I have failed to find any record of this important truth, and shall be glad to know if my observations have been anticipated.

Prof. Cotterill, in his work on the steam-engine (p. 33), referring to the process of formation of steam under rising pressure in a closed vessel, says:—"The mixture of steam and water must be supposed so treated that the temperature is sensibly uniform. If the experiment were tried without proper precautions, the steam would probably be found to be of higher temperature than the water—that is, it would be superheated." So far as my observations go, this is impossible, and the steam is never superheated by compression in a closed vessel, in contact with water.

In a small experimental boiler the records of temperature indicated as follows:—

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#### Temperatures in Model Boiler working up to 10 pounds pressure

| Water temperature<br>1½ inches below upper<br>level. | Steam temperature.<br>Thermometer in steam<br>space. | Pressure, pounds per<br>square inch. |
|------------------------------------------------------|------------------------------------------------------|--------------------------------------|
| ° F.                                                 | ° F.                                                 |                                      |
| 100                                                  | 87                                                   | —                                    |
| 120                                                  | 106                                                  | —                                    |
| 140                                                  | 126                                                  | —                                    |
| 158                                                  | 145                                                  | —                                    |
| 174                                                  | 164                                                  | —                                    |
| 188                                                  | 179                                                  | —                                    |
| 200                                                  | 192                                                  | —                                    |
| 212                                                  | 205                                                  | —                                    |
| 215                                                  | 212                                                  | —                                    |
| 226                                                  | 222                                                  | 5½                                   |
| 236                                                  | 233                                                  | 9½                                   |
| 239                                                  | 235                                                  | 10                                   |
| 239                                                  | 235                                                  | 10                                   |
| 239                                                  | 235                                                  | 10                                   |

To avoid supersaturation of the steam it must be separated as promptly as possible from the water, which it projects, more or less, into the steam space. It is this which renders it so important in practice to secure the most active circulation. Provision for this, whereby the water falls, whilst the steam rises, can be made.

Uniformity of temperature of the boiler contents is of the utmost importance; and I was recently told by an able engineer, connected with the Midland Railway, that the unequal expansion of the boiler plates in locomotives on getting up steam was not only disastrous in its consequences, but *impossible* of prevention. Pursuing thermometric experiments, I found this not to be the case, and on a first trial of suitable apparatus, I obtained the following result:—

#### Model Locomotive Boiler, showing Hottest Water at the Bottom under 212° (October 24, 1891).

|                                  |     |     |     |     |     |     |     |     |     |
|----------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Upper level above fire... ..     | 60  | 80  | 90  | 100 | 110 | 120 | 130 | 140 | 150 |
| Temperature below furnace ... .. | 60  | 65  | 70  | 76  | 82  | 90  | 96  | 107 | 114 |
| Upper level above fire... ..     | 160 | 170 | 180 | 190 | 196 | 198 | 199 | 204 | 209 |
| Temperature below furnace ... .. | 122 | 134 | 156 | 176 | 200 | 204 | 206 | 208 | 209 |
| Upper level above fire... ..     | 212 | 212 | —   | —   | —   | —   | —   | —   | —   |
| Temperature below furnace ... .. | 210 | 212 | —   | —   | —   | —   | —   | —   | —   |

Lord Rayleigh's suggestion to use liquids of higher boiling-point than water, such as saline solutions, to get hotter steam whereby to raise the upper limit of temperature in a steam-engine, is not feasible. Increased elasticity of steam or increased tension was long since shown by John Sharpe ("Annals of Philosophy," vol. i. p. 459, 1813) to be due to a corresponding increase in its density. He pointed out that at 212° the density of steam was 150 times greater than at 32°, and at 252° it was twice as great as at 212°. Increasing the density of the liquid does not help us, but liquids of lower boiling-point yield vapours of higher density than steam at equivalent temperatures. Anhydrous ammonia vapour exerts a pressure of 4 atmospheres at 32°, and its density is about 0.2, whereas at 120° F. the pressure is in round figures 285 pounds on the square inch, and its density 0.850.

#### Properties of Saturated Steam as compared with Saturated (Anhydrous) Ammonia Vapour.

| Steam.                                       |                     |                                           | Anhydrous ammonia.                           |                     |                                            |
|----------------------------------------------|---------------------|-------------------------------------------|----------------------------------------------|---------------------|--------------------------------------------|
| Pounds per square inch above the atmosphere. | Temperature in ° F. | Weight of steam in pounds per cubic foot. | Pounds per square inch above the atmosphere. | Temperature in ° F. | Weight of vapour in pounds per cubic foot. |
| 15                                           | 249.8               | .07344                                    | 14.744                                       | 0                   | .1060                                      |
| 30                                           | 273.9               | .10790                                    | 32                                           | 20                  | .1639                                      |
| 60                                           | 307.2               | .17493                                    | 57.607                                       | 40                  | .2428                                      |
| 120                                          | 349.8               | .30503                                    | 113                                          | 70                  | .4096                                      |
| 165                                          | 372.8               | .40053                                    | 164.7                                        | 90                  | .5587                                      |

Regnault, Frost, Fairbairn, Tate, and others have shown that the rate of expansion of superheated steam is almost identical with that of air and other permanent gas, if calculated not too close to the temperature of maximum saturation. In passing steam through pipes heated by the hot gases from the furnace, the effect is not much, if any, better than using a trap to separate the water of condensation.

It is obvious that, for steam to pass from a boiler into a superheater, the latter can only be at the same pressure as the boiler, or somewhat lower, and the gasification in transit is not attended by increased density nor exalted tension; hence the failure of ordinary superheaters.

Practical engineers—makers of high-pressure engines for the trade—discovered long since that compression of steam at the end of each stroke, or steam cushioning, notwithstanding certain theoretical disadvantages, yielded an average efficiency greatly in excess of free discharge of steam from the cylinder. In this case superheating, of course, occurs, by compression, under circumstances insuring exalted tension; hence the economy. Hook's law, "*Ut tensio sic vis*," cannot be translated into "*Ut calor sic vis*."

JOHN GAMGEE.

The Laboratory, 3 Church Street, Westminster, S.W.,  
February 23.

### Poincaré's "Thermodynamics."

I FEAR M. Poincaré has not read my review of his book with sufficient attention. Otherwise he could hardly have written the letter printed in your last number.

The chief objections I made, taken in the *reverse* order of their importance, were

1. The work is far too much a mere display of mathematical skill. It soars above such trifles as historical details, while overlooking in great measure the experimental bases of the theory; and it leaves absolutely unnoticed some of the most important branches of the subject.

[Thus, for instance, Sadi Carnot gets far less than his due, Rankine is not alluded to, and neither Thermodynamic Motivity nor the Dissipation of Energy is even mentioned!]

2. It gives an altogether imperfect notion of the true foundation for the reckoning of absolute temperature.

3. It completely ignores the real (*i.e.* the statistical) basis of the Second Law of Thermodynamics.

If these are what M. Poincaré alludes to as "*reproches généraux, contre lesquels ma préface proteste suffisamment*," I can only express genuine amazement that a Preface should be capable of having such powers, and envy the man who is able to write one.

As to smaller matters:—I did not attack M. Poincaré's printer, I virtually said he was excusable under the circumstances. And as to the quite subsidiary question which M. Poincaré seems to think I regard as the most important, I have only to say that I could scarcely be expected to know that the words "*on n'a pu jusqu'ici constater l'existence des forces électromotrices, &c.*," imply, as M. Poincaré now virtually interprets them, "One has not yet been able to assign the origin of the electromotive forces, &c."

P. G. T.

4/3/92.

### The Function of a University.

YET one more definition—it is no part of the business of a University to *teach*, says Prof. Fitzgerald in NATURE of February 25 (p. 392). We have now the following definitions of the function of a University:—

1. It should be a mere examining body, *e.g.* the London University.

2. It is a place for the cultivation of athletics, good breeding, and gentlemanly behaviour.

3. At the University there should be taught classics, mathematics, and pure science.

4. The Professors of the University should teach *useful* subjects like mechanical and electrical engineering, medicine, &c., as at Cambridge.

5. The true function of the University is the teaching of *useless* learning.

6. It is no part of the business of a University to *teach*. Truly, a wide choice of definitions, and seeing that the teaching of applied science which has been developed "at schools, technical colleges, by patent-mongers and the trade,"

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aided "by a lot of savages," has been recently appropriated by the Universities, I have no doubt, when these degraded mortals have similarly worked out a system of teaching applied literature, that a seventh definition of the function of a University will be added later on, *viz.* :—

7. At the University, modern languages and literature are studied in such a way as to be of the greatest value to the nation at large.

As Prof. Fitzgerald relegates the teaching of things useful to the class of pariahs mentioned above, perhaps he will tell us whether he raises the study of mechanical and electrical engineering to the lofty position of uselessness, or whether he utterly condemns the appeal that is now being widely made—made even to technical teachers—for aid in the establishment of engineering laboratories at a University which has recently thought that the best place to obtain an assistant was a London technical college.

He thinks that students, "if they are so ill prepared that they have not acquired the art of learning, should go to a College, . . ." and not to the University. I presume, then, that they ought to go, for example, to the Colleges of Trinity or St. John's, but not to Cambridge; or to the Colleges of Balliol or Christ's, but on no account to Oxford. Perhaps this somewhat conflicting advice is the result of Prof. Fitzgerald's studying literature "for its own sake," as contrasted with studying language for the sense it conveys. Examples were recently given in a leader in one of the daily papers illustrating that the public utterances of some of the most prominent advocates of the compulsory teaching of Greek conclusively proved that it was not to improve their English that they had studied the classics.

In the same lucid way Prof. Fitzgerald adds: "The Bible produced very little effect until it was read in translations; and the danger of a pagan revival, if ancient literature were studied without the obstruction of difficult languages, is the best reason for insisting on those languages in a Christian University." Surely a man of his wide intellectual power cannot mean that the general reading of the Bible, which became possible after it was translated into modern languages, is to be deplored. But neither, on the other hand, can he mean that the incalculable benefit, that has resulted from the translation of the Bible into the vulgar tongue is an argument for the suppression of free translation. On whichever horn of his own dilemma he decides to pose himself, I, at any rate, have no sympathy with the Roman Catholic dogma that good comes from making the knowledge of the truth difficult of attainment by the world at large.

He chides me with forgetting the debt electrical science owes to those who studied it while useless. Does the statement that one *Volt* sends one *Ampere*—that is, one *Coulomb* per second—through one *Ohm* look as if the practical electrical engineer had forgotten the labours of Volta, of Ampère, of Coulomb, and of Ohm? Indeed, is not Prof. Fitzgerald himself forgetting the deep debt of gratitude the theoretical study of electricity owes to its practical applications? The late Prof. Fleeming Jenkin, a Professor at a University bear in mind, wrote in 1873:—"In England at the present time it may almost be said that there are two sciences of electricity—one that is taught in ordinary text-books, and the other a sort of floating science known more or less perfectly to practical electricians. . . . A student might have mastered Delarive's large and valuable treatise, and yet feel as if in an unknown country and listening to an unknown tongue in the company of practical men. It is also not a little curious that the science known to the practical men was, so to speak, far more scientific than the science of the text-books."

While there are University Professors like Thomson, Hertz, and Fitzgerald, what matters it whether we call them the *teachers* or ourselves the *learners*? When the work they are now carrying on may be of incalculable service to the practical man in the future, of what avail is it to discuss whether it is to-day *useful* or *useless*? For the labours of such men I have too profound a respect and admiration to "sneer" at what I hold to be the true function of the University.

But equally worthy of respect do I think is the *teacher* in a *school* of engineering—that is, one who aims at presenting useful knowledge, and the methods for extending it, in such a form as to be most easily grasped by those who intend to devote their lives to engineering.

My friend Prof. Fitzgerald and I are at any rate wholly in accord on one important point urged in my recent inaugural address, *viz.* that it is the special function of the technical school to teach *useful* knowledge.

W. E. AYRTON.